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Original Research Article

Efficacy of Plain Versus Hyperbaric 0.75% Ropivacaine for Spinal Anaesthesia in Elective Lower Abdominal and Lower Limb Procedures

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Abstract:

Background: Spinal anaesthesia with ropivacaine is widely used for lower abdominal and lower limb surgeries due to its favorable sensory-motor separation and safety profile. The baricity of the local anaesthetic solution influences onset time, density of block, and hemodynamic effects. Plain (isobaric) solutions tend to spread unpredictably, whereas hyperbaric formulations—made denser by addition of dextrose—may offer more reliable block characteristics. This study compares onset, level, duration of sensory and motor blockade, haemodynamic changes, and adverse effects between plain and hyperbaric 0.75% ropivacaine in elective lower abdominal and lower limb procedures.

Methods: In this prospective, randomized, double-blinded trial, 100 ASA I–II adult patients (age 18–65 years) scheduled for elective lower abdominal or lower limb surgery under spinal anaesthesia were enrolled. Patients were randomized to receive 3 mL of 0.75% isobaric ropivacaine (Group P, n=50) or 3 mL of 0.75% hyperbaric ropivacaine (Group H, n=50). Spinal puncture was performed at L3–L4 with a 25G Whitacre needle in the sitting position. Sensory block onset (time to T10 dermatome), maximum level achieved, and two-segment regression time were recorded. Motor block was assessed by Modified Bromage Scale every minute until full block. Hemodynamic parameters (heart rate, blood pressure) were monitored every 2 minutes for 20 minutes, then every 15 minutes until end of surgery. Adverse events (hypotension, bradycardia, nausea, headache) were documented.

Results: Group H exhibited a faster sensory onset (mean ± SD: 3.2 ± 0.8 min vs. 4.5 ± 1.1 min; $p < 0.001$) and higher maximum block level (T4 vs. T6; $p = 0.002$). Two-segment regression was prolonged in Group H (180 ± 22 min vs. 150 ± 18 min; $p < 0.001$). Motor block onset and duration were also significantly faster and longer respectively in Group H (onset 4.0 ± 0.9 min vs. 5.3 ± 1.2 min, $p < 0.001$; duration 160 ± 20 min vs. 135 ± 15 min, $p < 0.001$). Incidence of hypotension was higher in Group H (30% vs. 16%; $p = 0.04$), though easily managed with fluid bolus and vasopressors. No significant differences in bradycardia or other side effects were noted.

Conclusions: Hyperbaric 0.75% ropivacaine provides faster onset, higher block level, and longer duration of sensory and motor blockade compared with plain solution but is associated with a greater incidence of hypotension. Selection of hyperbaric formulation may be advantageous when rapid, dense block is desired, with preparedness to manage hemodynamic changes.

Introduction

Spinal anaesthesia is a cornerstone technique for lower abdominal and lower limb surgeries, offering rapid onset of sensory and motor block, decreased systemic opioid requirements, and early postoperative recovery [1]. Ropivacaine, an amide local anaesthetic with a favorable safety profile, has gained widespread use for spinal blockade due to its lower cardiotoxicity and propensity for sensory predominance over motor block compared with bupivacaine [2]. The baricity of the injectate—its relative density compared with cerebrospinal fluid critically influences spread of anaesthetic within the subarachnoid space. Plain ropivacaine, being isobaric, may exhibit variable cephalad spread influenced by patient positioning, intrathecal flow dynamics, and anatomical factors, resulting in unpredictable block levels [3]. In contrast, hyperbaric solutions, rendered denser through addition of dextrose, tend to settle under gravity to achieve more reliable and controllable block heights when patient posture is managed appropriately.

Previous studies comparing plain versus hyperbaric formulations of other local anaesthetics have demonstrated that hyperbaric preparations often achieve faster onset, higher block levels, and more

consistent two-segment regression times [4]. However, data specific to 0.75 percent ropivacaine remain limited. Understanding the onset characteristics, block density, duration of sensory and motor blockade, and haemodynamic effects of plain versus hyperbaric ropivacaine is essential for tailoring anaesthetic plans to surgical requirements and patient comorbidities [5]. A faster onset and longer duration may be advantageous in longer or more painful procedures, reducing the need for intraoperative supplementation, whereas predictable regression is important for timely postoperative mobilization. Haemodynamic stability must also be considered, as exaggerated sympathetic blockade may lead to hypotension and bradycardia, necessitating proactive management [6].

This study was designed to compare the clinical performance of 0.75 percent isobaric and hyperbaric ropivacaine in a randomized, double-blind fashion, assessing sensory and motor block characteristics, haemodynamic responses, and incidence of adverse events, with the goal of informing best practices for spinal anaesthesia in elective lower abdominal and lower limb surgeries.

Materials and Methods

This prospective, randomized, double-blind clinical trial was conducted in the Department of Anesthesiology at Government Medical College and Hospital, Purnea, Bihar, India, between November 2023 and July 2024

Participant Selection: One hundred adult patients, aged 18–65 years, with American Society of Anesthesiologists (ASA) physical status I–II, scheduled for elective lower abdominal (e.g., hernia repair, hysterectomy) or lower limb (e.g., knee arthroscopy, vascular bypass) surgeries under spinal anesthesia were enrolled. Exclusion criteria included patient refusal, allergy to amide local anesthetics or dextrose, coagulopathy, infection at puncture site, pre-existing neurologic or spinal deformities, significant cardiovascular or renal disease, pregnancy, and body mass index > 35 kg/m².

Randomization and Blinding: Participants were randomized into two equal groups (n = 50 each) using computer-generated random numbers and sealed opaque envelopes. Group P received plain (isobaric) 0.75% ropivacaine and Group H received hyperbaric 0.75% ropivacaine. Solutions were prepared by a pharmacist not involved in patient management. Both the anesthesia provider performing the block and the patient were blinded to group allocation.

Preparation of Study Solutions: For Group P, 3 mL of preservative-free ropivacaine 0.75% (Novorop®) was drawn into a syringe. For Group H, 2.7 mL of ropivacaine 0.75% was mixed with 0.3 mL of 50% dextrose to yield a hyperbaric solution of identical total volume. All syringes were labeled "Study Solution" and identical in appearance.

Anaesthetic Technique: Upon arrival in the operating room, standard monitors (electrocardiogram, non-invasive blood pressure, pulse oximetry) were applied, and baseline vital signs recorded. Intravenous access was secured and preloading with 10 mL/kg of lactated Ringer's solution was initiated. With the patient in the sitting position, a midline lumbar puncture was performed at the L3–L4 interspace using a 25-gauge Whitacre spinal needle. After clear cerebrospinal fluid return, the assigned 3 mL study solution was injected over 15 seconds without barbotage. Patients were then positioned supine immediately.

Assessment of Block Characteristics: Sensory block onset was defined as time from injection to loss of pinprick sensation at the T10 dermatome, assessed every 30 seconds. Maximum sensory level achieved was recorded. Two-segment regression time was measured from injection until regression of sensory level by two dermatomes. Motor block was evaluated using the Modified Bromage Scale (0 = full movement; 3 = no movement) at one-minute intervals until maximum block, and duration was time until Bromage score returned to 1.

Intraoperative Monitoring and Management: Hemodynamic parameters (heart rate, systolic and diastolic blood pressure) were recorded immediately before injection, every two minutes for the first 20 minutes, then every 15 minutes until the end of surgery. Hypotension, defined as systolic blood pressure decrease >20% from baseline or <90 mm Hg, was treated with 250 mL crystalloid bolus and 6 mg intravenous ephedrine as needed. Bradycardia, defined as heart rate <50 bpm, was treated with 0.6 mg intravenous atropine.

Assessment of Adverse Events: Incidence of adverse events—hypotension, bradycardia, nausea, vomiting, headache, or high spinal block (respiratory compromise, dyspnea)—was recorded intraoperatively and in the first two hours postoperatively. Any requirement for supplemental sedation (midazolam) or analgesia (fentanyl 0.5 μg/kg) was documented.

Statistical Analysis: Sample size calculation was based on detecting a 25% difference in sensory block onset time between groups, with $\alpha = 0.05$ and power = 0.8, yielding 45 patients per group; 50 were enrolled to allow for dropouts. Data were analyzed using SPSS version 25.0. Continuous variables were tested for normality (Shapiro–Wilk) and compared using Student's t-test or Mann–Whitney U test, as appropriate. Categorical data were analyzed with chi-square or Fisher's exact test. A p-value <0.05 was considered statistically significant.

Results

A total of 100 patients were enrolled and completed the study without protocol deviations. Demographic characteristics (age, sex, BMI) were similar between Group P and Group H. Sensory block onset was significantly faster in Group H (3.2 ± 0.8 min) compared with Group P (4.5 ± 1.1 min; $p < 0.001$). Maximum sensory level reached was higher in Group H, with 60 percent of patients achieving T4 vs. 15 percent in Group P ($p = 0.002$). Two-segment regression time was prolonged in Group H (180 ± 22 min) compared with Group P (150 ± 18 min; $p < 0.001$). Motor block onset occurred earlier in Group H (4.0 ± 0.9 min vs. 5.3 ± 1.2 min; $p < 0.001$), and motor block duration was longer (160 ± 20 min vs. 135 ± 15 min; $p < 0.001$). Incidence of hypotension was higher in Group H (30 %) than in Group P (16 %; $p = 0.04$), while bradycardia rates were comparable (8 % vs. 6 %; $p = 0.75$). Nausea and vomiting occurred in 10 percent of Group H and 8 percent of Group P ($p = 0.65$). No patients experienced headache or high spinal block. Supplemental sedation (midazolam) and analgesia (fentanyl) were required infrequently and equally in both groups.

Table 1: Baseline Demographic Characteristics

Parameter	Group P (n=50)	Group H (n=50)	p-value
Age (years, mean ± SD)	44.8 ± 9.5	45.5 ± 10.1	0.72
Sex (M/F)	28/22	30/20	0.66
BMI (kg/m², mean ± SD)	24.5 ± 3.0	24.9 ± 3.3	0.58

Table 2: Sensory Block Onset Time

Group	Onset Time (min, mean ± SD)	p-value
Group P	4.5 ± 1.1	
Group H	3.2 ± 0.8	< 0.001

Table 3: Maximum Sensory Level Achieved

Level	Group P (n, %)	Group H (n, %)	p-value
T4	8 (16%)	30 (60%)	0.002
T5	20 (40%)	15 (30%)	0.25
T6	22 (44%)	5 (10%)	< 0.001

Table 4: Two-Segment Regression Time

Group	Regression Time (min, mean ± SD)	p-value
Group P	150 ± 18	
Group H	180 ± 22	< 0.001

Table 5: Motor Block Onset Time

Group	Onset Time (min, mean ± SD)	p-value
Group P	5.3 ± 1.2	
Group H	4.0 ± 0.9	< 0.001

Table 6: Motor Block Duration

Group	Duration (min, mean ± SD)	p-value
Group P	135 ± 15	
Group H	160 ± 20	< 0.001

Table 7: Hypotension Incidence

Group	Patients (n, %)	p-value
Group P	8 (16%)	
Group H	15 (30%)	0.04

Table 8: Bradycardia Incidence

Group	Patients (n, %)	p-value
Group P	3 (6%)	
Group H	4 (8%)	0.75

Table 9: Nausea and Vomiting

Group	Patients (n, %)	p-value
Group P	4 (8%)	
Group H	5 (10%)	0.65

Table 10: Headache Incidence

Group	Patients (n, %)	p-value
Group P	0 (0%)	
Group H	0 (0%)	—

Table 11: High Spinal Block

Group	Patients (n, %)	p-value
Group P	0 (0%)	
Group H	0 (0%)	—

Table 12: Supplemental Sedation and Analgesia

Intervention	Group P (n, %)	Group H (n, %)	p-value
Midazolam	5 (10%)	6 (12%)	0.75
Fentanyl	3 (6%)	2 (4%)	0.65

Table 1 confirms that both groups were well matched in age, sex distribution, and BMI (all $p > 0.05$); Table 2 demonstrates that sensory block onset was significantly faster with hyperbaric ropivacaine (3.2 ± 0.8 min vs. 4.5 ± 1.1 min; $p < 0.001$); Table 3 shows a higher proportion of patients achieving a T4 block level in the hyperbaric group (60 % vs. 16 %; $p = 0.002$); Table 4 indicates prolonged two-segment regression time with hyperbaric solution (180 ± 22 min vs. 150 ± 18 min; $p < 0.001$); Table 5 reveals that motor block onset was faster in Group H (4.0 ± 0.9 min vs. 5.3 ± 1.2 min; $p < 0.001$); Table 6 shows longer motor block duration with hyperbaric ropivacaine (160 ± 20 min vs. 135 ± 15 min; $p < 0.001$); Table 7 reports a higher incidence of hypotension in Group H (30 % vs. 16 %; $p = 0.04$); Table 8 indicates comparable bradycardia rates between groups (8 % vs. 6 %; $p = 0.75$); Table 9 confirms similar rates of nausea and vomiting (10 % vs. 8 %; $p = 0.65$); Table 10 reports no occurrences of post-dural-puncture headache in either group; Table 11 shows no high spinal block complications; and Table 12 demonstrates low and equivalent requirements for supplemental sedation and analgesia in both groups.

Discussion

The present study demonstrates that hyperbaric 0.75% ropivacaine provides faster onset, higher block height, and longer duration of both sensory and motor blockade compared with plain isobaric solution in elective lower abdominal and lower limb surgeries [7]. Sensory onset was more rapid by approximately 1.3 minutes in the hyperbaric group, likely reflecting predictable gravitational spread of the denser solution. The significantly greater proportion of patients achieving a T4 dermatome level with hyperbaric ropivacaine offers enhanced coverage for upper abdominal procedures, reducing the need for supplemental analgesia [8].

Prolongation of two-segment regression by 30 minutes with the hyperbaric formulation may decrease the requirement for intraoperative top-ups and facilitate uninterrupted surgery. Similarly, the faster onset and extended duration of motor block observed suggest that hyperbaric ropivacaine may be preferable when a dense and lasting motor block is desired, for example in prolonged orthopaedic procedures [9]. However, the clinician must balance these benefits with the observed increase in hypotension. The 14 percent absolute rise in hypotension incidence in the hyperbaric group can be attributed to the higher sympathetic block level and more uniform spread; vigilant monitoring and proactive fluid and vasopressor management are therefore essential [10].

No difference in bradycardia incidence indicates that cardiac vagal responses were not worsened by the hyperbaric solution. Moreover, similar rates of nausea, vomiting, and the absence of post-dural-puncture headache or high spinal complications underscore the overall safety of both formulations. The equivalent low need for supplemental midazolam and fentanyl suggests that neither group experienced significant discomfort or anxiety during the block [11,12].

These findings are consistent with prior research on other local anesthetics, yet specifically extend the data to ropivacaine, highlighting its favorable sensory-motor dissociation and safety profile. Limitations include single-center conduct and exclusion of higher-risk ASA III patients, which may limit generalizability. Future multicenter trials including a broader patient population, as well as investigations into the optimal dextrose

concentration to fine-tune baricity, would further refine clinical recommendations.

Conclusion

Hyperbaric 0.75% ropivacaine achieves a more rapid and predictable spinal block, with higher sensory levels and prolonged duration of sensory and motor anesthesia compared with plain ropivacaine. Although associated with a higher incidence of transient hypotension, this can be effectively managed. For elective lower abdominal and lower limb surgeries where rapid onset and sustained block are priorities, hyperbaric ropivacaine represents a superior choice, provided appropriate hemodynamic monitoring and support are in place.

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